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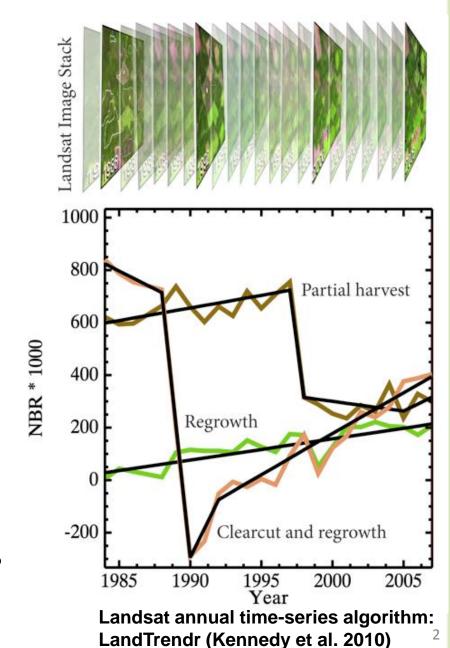
> ¹ Oregon State University ²USDA Forest Service

Background:

- Annual time-series to detect slow and abrupt forest change (e.g. LandTrendr)
- Improved MSS radiometry
- Potential to extent annual disturbance history to 1972

Can we combine MSS and TM data for time-series analysis?

- MSS-TM differences in spectral bands
- Radiometric and geometric quality of MSS



Study area

<u>Location:</u> Pacific Northwest, Eastern Oregon, Blue Mountains

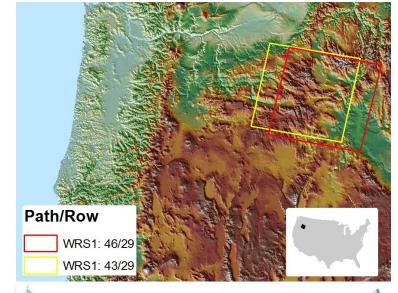
Forest type: Conifers (Ponderosa pine, Douglas fir, Western Juniper, Larch), Hardwoods confined to riparian areas

<u>Disturbances:</u> thinning & clear-cut harvest, insect outbreaks and frequent low intensity fires, grazing

Precipitation: 305 mm-1,270 mm

Terrain: mountainous (~500-2700m)

WRS-1: 4329, WRS-2: 4629-4729

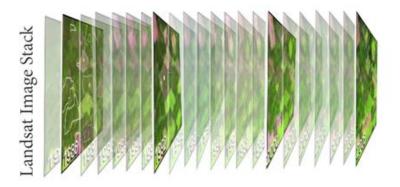




Method:

Compile Image Stack

- Vegetation period (Jul/Aug)
- Annual images 1972-2010

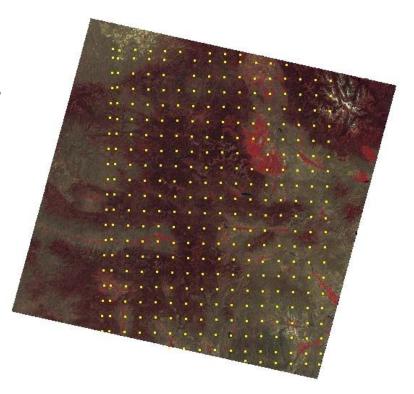


Method:

- ~80% L1T corrected
- 63% of L1T scenes show RMSE > 1 pixel, 20% > 1.5 pixel.
 - -> Further geometric correction of L1T required for accurate time-series analysis
- Automated image tie-point program (Kennedy and Cohen, 2003) and 2nd-order polynomial transformation reduced RMSE < 0.5 pixel
- Final temporal coverage:

Compile Image Stack

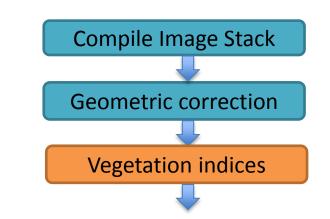
Geometric correction

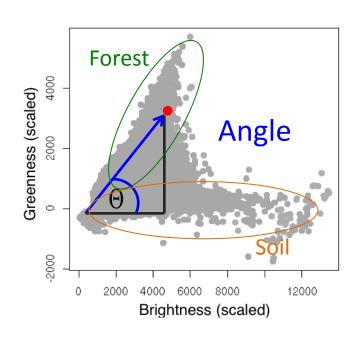


MSS 1-3 (4629) MSS 4-5 (4329) TM/ETM+ (4329)

Method:

- Vegetation indices used in univariate timeseries algorithms
- NDVI, Tasseled Cap for MSS & TM/ETM+
- TM & MSS tasseled cap conceptually similar in the first two components
- Calibration is required between MSS and TM data to bridge sensor differences (e.g. spectral and dynamic range)
- SWIR-based indices work better (NBR, Wetness), but MSS lacks SWIR band





Powell et al. (2010)

Calibration Step 1:

- Post-calibration dynamic ranges changed with new LPGS-processed MSS data, plus they vary between MSS sensors
- Converted Kauth et al. (1979) coefficients such that new MSS TC aligns with the Kauth transformation

1)
$$Q_RG_R + B_R = L_R$$

2) $Q_RG_R + B_R = QG + B$
3) $Q_R = (E*B-B_R)/G_R + Q*E*G/G_R$

$$E = \frac{ESUN_R}{ESUN}$$

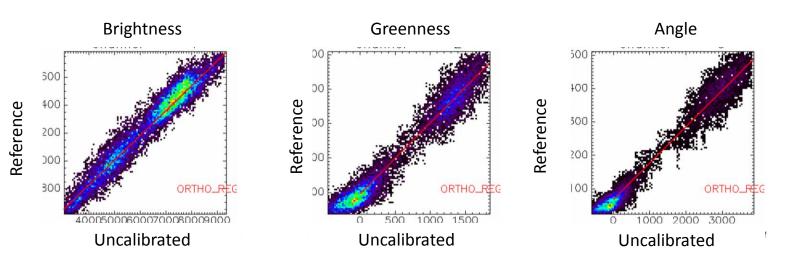
4) $TC^1 = \beta_R^1 Q_R^1 + \beta_R^2 Q_R^2 + \beta_R^3 Q_R^3 + \beta_R^4 Q_R^4$ 5) $TC^1 = \beta_R^1 G_A^1 Q^1 + \beta_R^1 B_A^1 + \beta_R^2 G_A^2 Q^2 + \beta_R^2 B_A^2 + \beta_R^3 G_A^3 Q^3 + \beta_R^3 B_A^3 + \beta_R^4 G_A^4 Q^4 + \beta_R^4 B_A^4$ 6) $TC^1 = \beta^0 + \beta^1 Q^1 + \beta^2 Q^2 + \beta^3 Q^3 + \beta^4 Q^4$ Standardized TC-coefficients

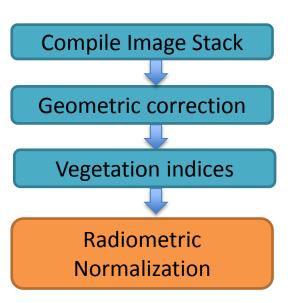
Calibration Step 2:

Automatic Radiometric Normalization (Canty et al. 2004)

- Normalize all images to a single reference
- Based on pseudo-invariant pixels
- Reference: atmospherically corrected TM image

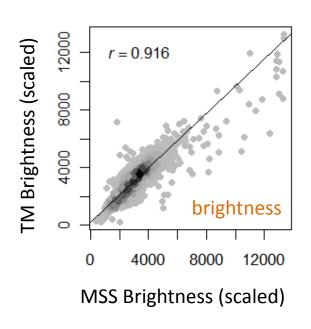
Mean correlation no-change pixels: 0.98

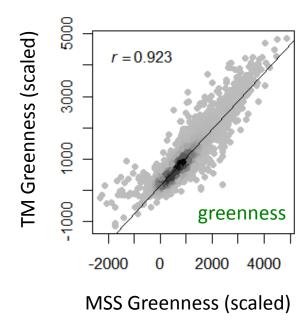


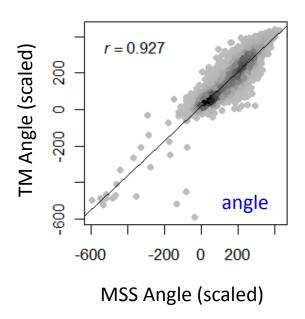


Coincident MSS/TM

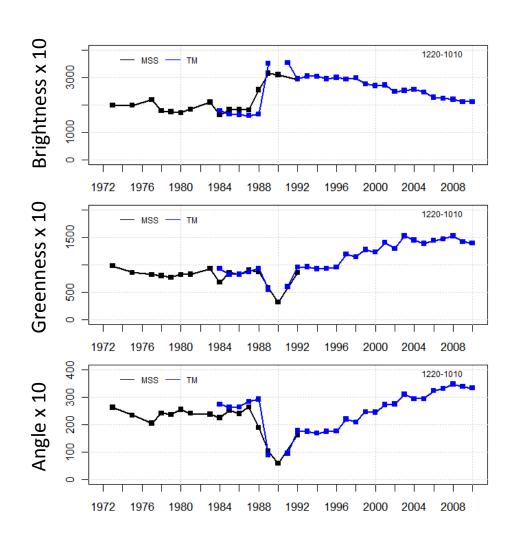
Strong correlation between MSS and TM Tasseled Cap

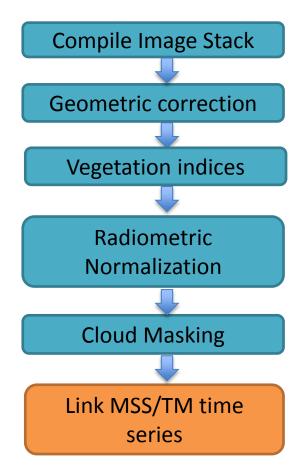




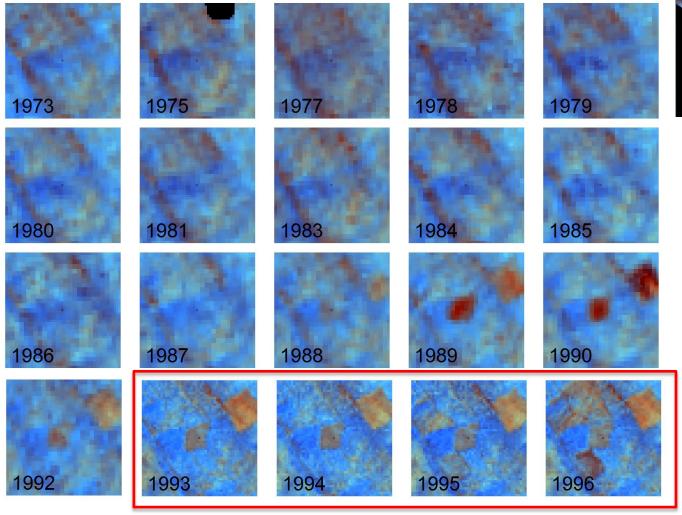


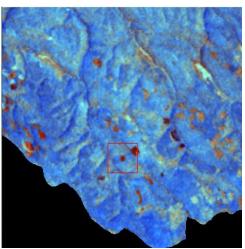
MSS/TM time series





MSS/TM time series





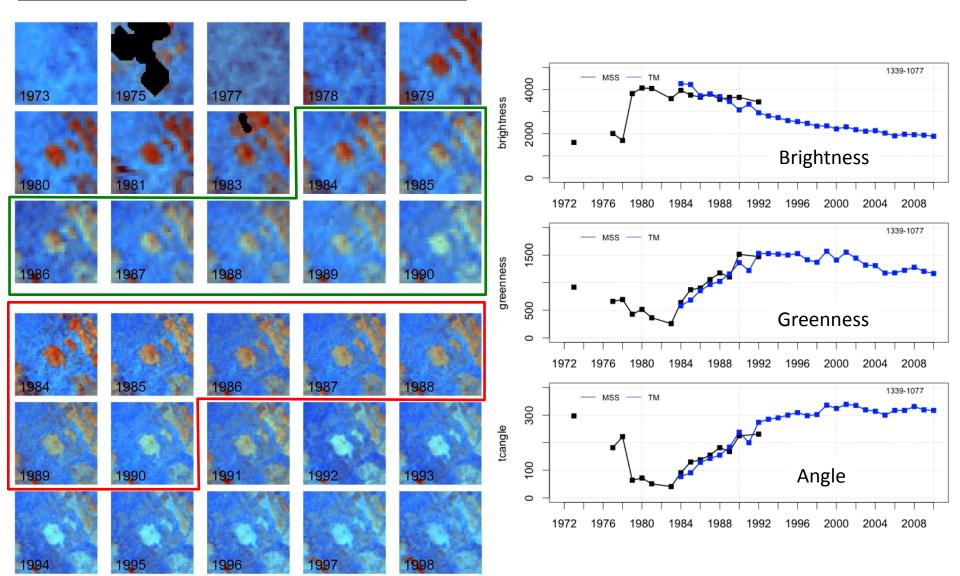
R: Brightness

G: Greenness

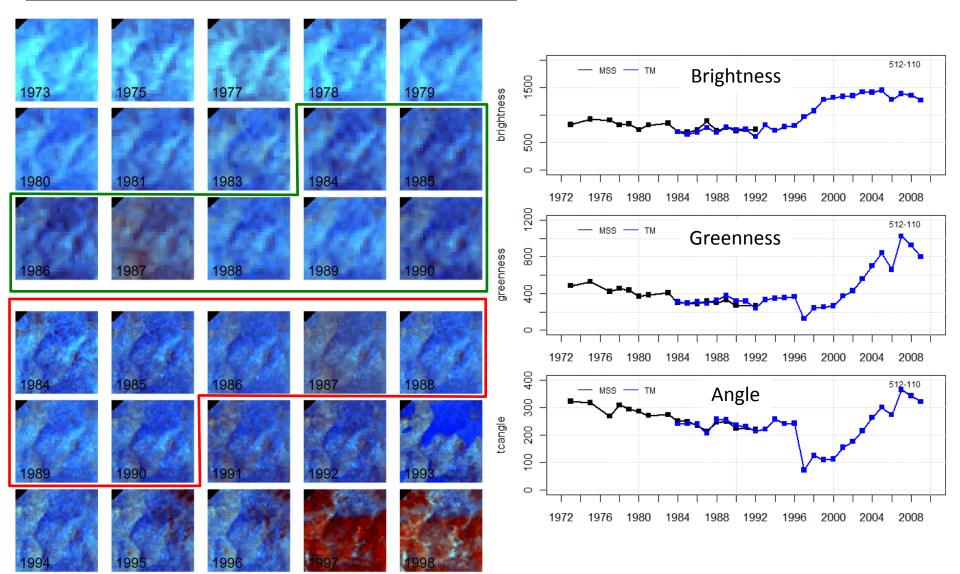
B: Angle

Landsat TM

Harvest followed by regrowth



Fire preceded by insect damage:



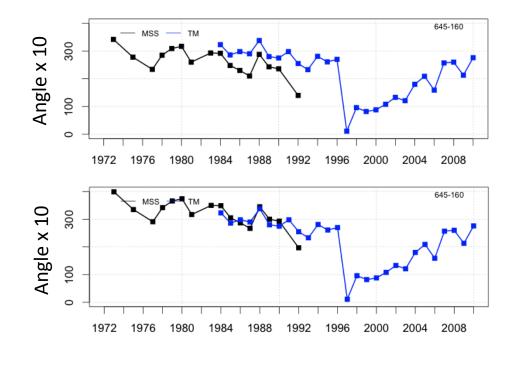
Alignment of time series

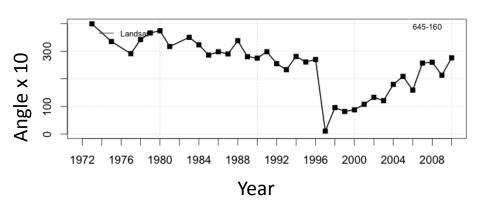
- 1. Image-level normalization RMSE= 3.1 (+/- 1.2 SD)
- 2. Pixel-level MSS alignment

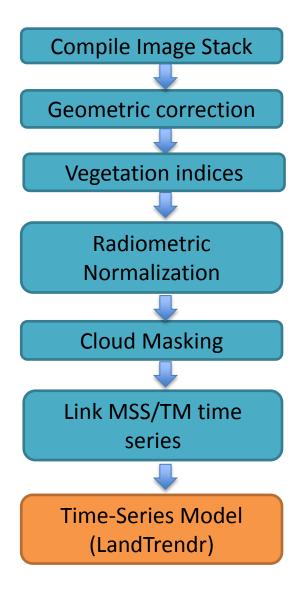
$$CF = \frac{1}{N} \stackrel{N}{\underset{i=1}{\circ}} MSS_i - TM_i$$

$$MSS_{i}^{\Diamond} = MSS_{i} - CF$$

3. Combined time series







Method Summary:

3-step calibration of MSS tasseled cap

- 1. MSS TC coefficient adjustment
- 1. Scene-level radiometric normalization
- 1. Pixel-level MSS-to-TM alignment

Summary:

- High correlation between MSS and TM tasseled cap components
- Comparison of MSS and TM time-series indicates good agreement in the overlapping time period
- Both abrupt and slow disturbance seem to be captured across the time series
- TC ANGLE is promising to describe annual forest change history between 1972-2010 using time-series models such as LandTrendr

Acknowledgements

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